BIO-DYNAMICS

A periodical furthering soil conservation and increased fertility in order to improve nutrition and health.

WINTER 1950–51

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VOL. IX No. 1

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BIO-DYNAMIC FARMING AND GARDENING ASSOCIATION, INC.

R. D. 1, CHESTER, NEW YORK

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SOIL IMPROVEMENTS WITH THE BIO-DYNAMIC METHOD

EHRENFRIED PFEIFFER

The farm which is reported on here was purchased in March 1944. It is located in the Seely Creek Valley on Chester-Greenwood Lake Road, about five miles southeast of Chester, N. Y. The soils are medium heavy, brown alluvial soils, with lots of stones. The subsoil of the bottom land is heavy blue and yellow clay, of the hillsides gravel and rock. About one third of the farm area consists of bottom land, the rest of hillsides with some steep slopes, partly with rather shallow soils. The total acreage surveyed is around 150, divided into 21 field lots. Some of the fields are only 1 to 2 acres in extent, others range from 3 to 6 acres. The farm soils were neglected when the place was taken over, but they were not run-down nor had they been overused. Massive doses of fertilizer had not been given and the soils had not been over-limed. Cultivation practices applied under the present management are: to subsoil and plow for corn; to subsoil and plow, or disk, for the seeding of winter wheat. In the beginning, the crop rotation for the arable fields was: (1) corn for silage with 10 tons of manure per acre; (2) winter wheat with a seeding of grasses and clovers; (3) to (5) hay and late summer and fall grazing; (6) soybeans. This has now been changed to the following: (1) soybeans in plowed up pasture or hayland, after-crop or winter cover crop of rye; (2) corn with 10 tons of manure per acre; (3) winter wheat or oats with grass and clover or alfalfa seedings; (4) to (6) one or two cuttings of hay and aftergrazing. It has been our observation that our grass and clover mixtures last for 4 years at least, in some cases the clover has lasted as long as 5 years, and on some of the best drained fields clover and alfalfa have come back as volunteer crops.

One of the first and most essential steps is to work out good and effective drainage. Subsoiling, wherever possible, is vital and pays dividends in earlier access to fields in the spring, greater resistance to drought, an easier catch of grasses and clover, and deeper growing roots. This matter of good drainage is stressed here because it has been found that often it is poor drainage which lies at the root of many problems of soil fertility.

Turning back to the report: the bio-dynamic spray preparations 500 and 501 have been applied and all of the manure has

been treated with preparations 502 to 507. All land which is plowed for corn receives treated manure, but very little top-dressing of pastures or hayfields has been done so far. It has been observed that the rather intensive use of treated manure per acre (10 tons for instance) is more effective in the long run, than a more scattered application of smaller amounts over larger areas. Only after a healthy, live structure has been established does it pay to follow up with smaller amounts as a top-dressing. On run-down fields and sods it is advisable first to top-dress and then plow. Soybeans have proved to be the most successful first crop on plowed sods (especially in the case of old pastures or run-down land), in outgrowing weeds and improving the soil structure.

Some soil tests were made on a few fields in 1944; since 1947 tests have been made regularly every year. The samples were taken each year at the end of March or early in April, after the frost had gone out of the ground and the land dried. For humus as well as for available mineral tests the La Motte equipment has been used. Some of the results of these tests are presented in the following tables:

ORGANIC MATTER CONTENTS AND PERCENT OF SOILS IN THE VARIOUS RANGES

Percent of Organic Matter	Percent of Soils 1947	1950
1 to 3%	23.7	18.2
3 to 4%	47.1	31.8
4 to 5%	29.2	45.5
5 to 6%	0	4.5

The shift from a lower organic matter contents to a higher one is clearly visible, or in other words, the decrease of poorer and the increase of good soils.

SOIL REACTION AND CORRESPONDING PERCENT OF SOILS

Range of pH	Percent of Soils 1947	1950
5.0 - 5.4	45	9.1
5.5 - 5.9	25	18.2
6.0 - 6.4	15	40.9
6.5 - 6.9	10	22.7
7.0	5	9.1

The decrease in the number of acid fields and the increase of the number of less acid and near neutral soils is evident, even

in so short a period as three years. Since we began to subsoil, to a small extent, only somewhat more than a year ago, the decrease in acidity is not yet due to the improved drainage but to the general management of the fields.

The most striking result of the bio-dynamic management has probably been the increase of nitrate nitrogen. While the soils averaged 15 lbs. of nitrate nitrogen per acre in 1947, they now average 48.2 lbs. per acre, and some even reach the height of 190 to 200 lbs. per acre. Here it is important to realize that manure was given at the rate of 8-10 tons per acre only once in 4-5 years to the manured crop, corn in our case, and that no other nitrogen-containing fertilizer has been applied since 1944. The increase of nitrogen above and beyond the manure application is entirely due to the bio-dynamic spray 500, the increase of soil bacteria in connection with the rising content of organic matter and the decrease of acidity.

This whole process is also reflected in the change in the bacterial life from an average count of 115 Million bacteria per gram in 1948 to 2451 Million bacteria per gram in 1950. (These averages do not include 2 fields which in 1948 each had a count of 5000 Million.) In 1950 only three fields out of 17 were below the 500 Million mark. For purposes of comparison, it may be mentioned that, on the average, on other farms we counted 150 to 250 Million in fair to moderately good fields, and that 500 Million is the average count of the best, fertile, black soils of the Middle West. Counts of better than 800 Million are very unusual.

The changes in available phosphates and potassium do not follow a clear enough pattern as yet so that they can be fully understood. As far as leaf symptoms of deficiencies go, none were observed. Available phosphates have increased on 9 fields, over a four-year period, from an average of 116 lbs./acre to 160 lbs./acre. Only one of the 9 fields had received a superphosphate top-dressing of 400 lbs./acre. The others had received manure, some only a slight top-dressing of 5 tons/acre, the others 8 tons/acre; in most cases the manure was applied three to four years ago, only one field had received an application recently. All had been treated with the bio-dynamic preparation 500. Four fields maintained a rather low level of 100 lbs./acre. One of these fields had phosphate fertilizer; three had been given manure; all four were not too well drained. On four other fields the available phosphate declined from an average of 190 lbs./

acre to 162 lbs./acre. Two of these fields had a top-dressing with 400 lbs./acre of a 16% superphosphate, but none of the four received preparation 500. The increased bacteria count parallels the increase of organic matter and the availability of phosphates. The opinion has been voiced that in organic soils preparation 500 increases the availability of phosphate. This was later confirmed in laboratory experiments.

The potassium history of the fields definitely shows that there is a higher availability of it with applications of manure. When manure is given only at long intervals of time the available potassium content of the soil gradually drops. Manure, therefore, is very important in order to maintain the potassium level. At the present stage of our knowledge, we prefer rather more frequent applications on soils with a high organic matter content. It seems that 500 does not increase the availability of potassium. In fact it helps to lock up the potassium in the soil so that less leaching occurs, as our laboratory experiments have shown. The following conclusions can be drawn from these last observations: (1) all possible steps should be taken to prepare the manure so as to avoid the washing out of potassium; (2) to collect all supplies of potassium including liquid manure. The farmer who flushes the liquid manure down the stable drain suffers a considerable loss of potassium. A liquid manure tank is consequently an important and well justified expense on a biodynamic farm.

VARIABLE LEVELS OF BIOLOGICAL ACTIVITY IN SANBORN FIELD AFTER 50 YEARS OF TREATMENT

WM. A. ALBRECHT

Professor William A. Albrecht is Chairman of the Department of Soils, College of Agriculture, University of Missouri, Columbia, Missouri. He has made, and is making, many invaluable contributions in the study of soils. This particular article is reprinted from the 1938 Proceedings of the Soil Science Society.

* * *

Sanborn Field, where the predominant soil treatment has been manure additions and some fertilizers in continuous cropping and different rotations, provides an opportunity to study the properties and the performances of the soil organic matter as an index of the biological activity in relation to soil management practices. After fifty years of treatment the organic matter fraction of the soil might well be expected to have some earmarks of stability in nature and behavior which could be recognized by analytical study.

The hypothesis for undertaking such a study is the belief that organic matter returned to the soil is a greater source of nutrients than commonly considered. Organic matter is readily recognized as the source of energy for the majority of soil chemical changes. As the source of carbon dioxide, we grant it a prominent place, and have been led to believe that in setting free this acidic agent through microbiological struggles, it serves to break the bases, or cations, out of the crystal minerals to be absorbed or held less firmly by the clay complex, and thus changed from the unavailable to usable forms for the plants. Skepticism toward such a belief in the mineral breakdown as the main source of nutrients for plants should arise from the acquaintance with the high ash content of the so-called "humus" or organic fraction taken from the soil. Also, the stability of the colloidal mineral, or clay fraction, under rather drastic chemical treatment in the laboratory, indicates its insignificant change during a single growing season. When organic matter decay reduces soil acidity, isn't such possibly the result more from oxidized alkali or alkaline earth residues left as ash than from basic residues liberated by rock and mineral breakdown under carbonic acid attack? By determining the more exact nature of the carbonaceous and nitrogenous fraction of the soil, and then by learning its rate of breakdown,—particularly dur-

ing the growing season,—it will be possible to learn whether or not this fraction of the soil is the main, or almost sole, contributor of nutrients to the plant during the growing season.

Sanborn Field is of the Putnam silt loam type in the Putnam-Vigo-Clermont association, whose profile consists of a silty surface underlain by an impervious horizon of compact clay. Its climatic equilibrium locates its surface acre nitrogen content at approximately twenty-five hundred to twenty-six hundred pounds. Its exchange capacity amounts to 13-15 M.E.[1] per 100 grams soil, and its degree of base saturation is about fifty per cent.

The cropping systems on Sanborn Field include continuous crops and rotations while the list of soil treatments contains manure, ammonium sulfate, sodium nitrate, superphosphate, complete fertilizers, and limestone. Some of these treatments have extended through only the last twenty-five years, while some have been regularly followed since the establishment of the field fifty years ago. Attempts have been made to learn something not only about the changes in the supply of the organic matter, but also about the nature of the organic matter, particularly the differences in its composition as shown (*a*) by the carbon and nitrogen contents, (*b*) by the differences in the extracted humus, (*c*) by the degree of lignification (woodiness), and (*d*) by the differences in rates of its nitrification. The studies on the nature of the organic matter of this old field were undertaken to learn more about the biochemical activity within a soil as related to its treatment in the hope that such knowledge might contribute to more wise soil management.

Changes in Supply of Organic Matter

Careful analyses of the plots for nitrogen and carbon were made at the end of twenty-five years and again after fifty years. Not all the plots will be cited here. Only a few of them have been selected for citation as they lend themselves for common use through the other phases of this study. Table 1 gives plots in continuous wheat and continuous timothy to illustrate the extremes in organic matter changes in the field.

Outside of the plots in continuous sods, the depletion of the organic matter is the characteristic not only of the plots cited in the table but for most of the plots. Since no analyses were made of the original soil, the change in the organic matter con-

(1) M.E. equals milliequivalents per 100 grams of soil. Exchange capacity indicates the quantity of materials which may be easily separated from a soil by an electrolytic process (that is, exchangeable bases and acids). Ed. BD.

Table 1

THE LIGNIN CONTENT OF THE ORGANIC MATTER AFTER FIFTY YEARS WITH THE CHANGES IN THE ORGANIC MATTER STOCK IN THE SOILS OF SANBORN FIELD DURING THE LAST TWENTY-FIVE YEARS

Plot No.	Crop and Treatment	Organic Matter Content % After 25 Years	After 50 Years	Change - or +	Lignin (%)
2	Wheat—Fertilizer	1.94	1.75	-.19	39.5
5	Wheat—Manure 6T, 25 yrs. Manure 3T, 25 yrs.	2.62	2.18	-.44	48.9
29	Wheat—Manure 6T, 25 yrs. Ammonium sulfate, 25 yrs.	2.37	1.84	-.53	46.1
30	Wheat—Manure 6T, 25 yrs. Sodium nitrate, 25 yrs.	2.77	2.24	-.33	50.5
23	Timothy—No treatment	2.29	2.49	+.20	40.5
22	Timothy—Manure 6T	2.91	3.51	+.60	48.8

tent, as based on carbon, is determinable for only the last twenty-five years. During this brief period the changes amount to as much as a loss of more than ten to twenty per cent in the original supply with continuous cultivated cropping and a gain of twenty per cent under continuous sod cropping.

Nature of the Organic Matter

The lowest supply of organic matter after fifty years occurs in Plot No. 2 under continuous wheat given heavy additions of commercial fertilizer. This seems to suggest that the addition of the nitrogen and minerals has supplied a microbiological deficiency, and that fertilizers served thus to deplete the organic matter further here than on any other plot. With over 750 pounds of mixed fertilizers, of which no small part was mineral nitrogen, the carbon supply of the soil has been extensively burned out. That the phosphate and potassium are essential contributions toward increased microbiological activity is testified to by the higher content of organic matter in the continuous wheat plots given ammonium sulfate and sodium nitrate. These are still higher at this time in organic matter than the plot given complete fertilizer. The ammonium sulfate treated wheat plot which is now very acid, is rapidly moving toward the lower level of organic matter found in the plot given complete fertilizer. If the minerals are deficient here the nitrification process may be liberating some from the mineral fraction of the soil.

These facts suggest that organic matter decay in the soils of many of the Sanborn Field plots is a much slower process because of the deficiency in phosphorus and possibly in potassium. The addition of mobile or soluble nitrogen is also instru-

mental in decomposing the organic matter or carbon as based on the determinations of this latter element. Thus, we may reason that the organic matter in the soils like those on Sanborn Field must be approaching a very stable condition. This stability would seem to rest on its highly carbonaceous nature, or its supply of immobile nitrogen, which does not serve microbiological life for its digestion or decay unless balanced or supplemented by soluble nitrogen and minerals. If this is the nature of the organic matter then its accumulation under the timothy would suggest such an occurrence because of a deficient supply of nitrogen, deficient phosphorus, and deficient minerals, or it may be simply remaining there because these deficiencies prohibit the microorganisms from decomposing or removing it.

Changes in the Nature of Organic Matter with Time

A study of the carbon-nitrogen ratios of these sample plots also points further to a wide difference in the nature of the organic matter, and, consequently a wide variation in microbiological activities. In Table 2 are presented the carbon-nitrogen ratios along with percentage contents of these elements for a few of the interesting plots.

The shift to a wider carbon-nitrogen ratio as a result of the nitrogen additions indicates a more active form of organic matter in the soil as a result of nitrogen fertilization. Even

Table 2

TOTAL CARBON AND NITROGEN CONTENTS TOGETHER WITH THEIR RATIOS AT TWENTY-FIVE-YEAR INTERVALS ON SANBORN FIELD

Plot No.	Crop and Treatment	After 25 Years			After 50 Years			Changes in Carbon	Changes in Nitrogen
		Carbon %	Nitrogen %	C/N	Carbon %	Nitrogen %	C/N		
2	Wheat—Fertilizer	1.13	.107	10.5	1.02	.100	10.3	-.11	-.07
5	Wheat—Manure 6T, 25 yrs. Manure 3T, 25 yrs.	1.52	.140	10.8	1.27	.119	10.6	-.25	-.21
29	Wheat—Manure 6T, 25 yrs. Ammonium sulfate, 25 yrs.	1.38	.145	9.5	1.07	.081	13.2	-.31	-.64
30	Wheat—Manure 6T, 25 yrs. Sodium nitrate, 25 yrs.	1.61	.171	9.4	1.30	.094	13.8	-.31	-.77
23	Timothy—No treatment	1.33	.141	9.4	1.45	.135	10.7	+.12	-.06
23	Timothy — Manure 6T	1.69	.177	9.5	2.04	.195	10.4	+.35	+.18

though the total supply in this soil was decidedly lowered as measured in terms of either carbon or nitrogen, yet this lower supply with its wider carbon-nitrogen ratio suggests less stable or more active compounds. These changes which occurred in

these nitrogen treated plots within twenty-five years suggest that the stage of activity was very low already twenty-five years ago, when the carbon-nitrogen ratio was very narrow, and that more activity is now prevalent in the material of wider ratio. On the wheat plot, given complete fertilizer, the nature of the organic matter changed little during twenty-five years as indicated by the stability of the carbon-nitrogen ratio, or its similarity in the two intervals. Manure additions, like-wise, maintained a stable carbon-nitrogen ratio, in the face of a declining total supply of organic matter. Under timothy without manure, the total carbon increased while the total nitrogen decreased, thus, giving a wider ratio. Where manure was applied on the timothy soil, the carbon-nitrogen ratio widened at the same time while the total organic matter increased. This suggests a tendency to hoard carbon. In four of the plots, whether manured or not, the carbon-nitrogen ratios were narrow but similar. They were much wider after twenty-five years where nitrogen was applied, even though the total organic matter supply was decidedly lowered during that same interval.

Nature and Quantity of the Extracted Humus

As a partial attempt to differentiate the organic matter on the different long continued plots, humus extracts were made of six of them, and analyzed for their contents in calcium, phosphorus and silica in addition to their carbon and nitrogen. These data are presented in Table 3.

Table 3

ANALYSES OF EXTRACTED HUMUS FROM SOME SANBORN FIELD PLOTS

Crop and Treatment		Soil Content	Humus Composition					
			Nitrogen	Carbon	C/N	Calcium	Phosphorus	Silica
		%	%	%		%	%	%
Corn	Manure	3.280	7.40	14.15	1.91	2.24	.710	6.08
	No Manure	3.218	3.45	8.76	2.54	2.12	.448	3.34
Timothy	Manure	4.712	7.09	14.11	1.99	1.71	.648	3.44
	No Manure	3.314	5.52	16.51	2.99	1.71	.842	2.82
Rotation	Manure	3.958	5.34	18.09	3.38	2.74	.724	5.70
	No Manure	3.322	4.99	17.07	3.42	1.56	.808	2.16

The total quantity of humus was lowest in the cultivated soil, followed closely by the soil in the rotation and that in timothy, both where no manure was used. They take this same order, but at a higher figure, where manure was added.

The nitrogen content of the humus varied from 3.45 to 7.40 per cent, with the high figures under corn with manure, and sod given the same treatment. The lowest nitrogen figure oc-

curred under corn that had no treatment. Under rotation, the manure addition gave the least variation in nitrogen content of this extract. These rotated plots and the sod plot without manure fluctuated closely around the nitrogen content of five per cent customarily considered as the average for humus.

The carbon content of the humus fluctuates from the high figure under the rotated soils to the low one under the corn without manure. In each case, the extract from unmanured soil is lower in carbon than from the manured soil. The carbon-nitrogen ratio is also wider for unmanured than for the manured soil, and points to relatively more nitrogen in this humus form as a consequence of manure additions. Manure nitrogen then must be retained, in part at least, in the more stable humus fraction of the soil.

The mineral contents of the humus are also widely different with the different soil treatments. Except for the timothy soil where the two analyses are the same, the calcium contents are higher for the soils with manure than for those with no manure. That the lowest calcium content should be in the untreated soil with rotation may not be causally related to the fact that this is the only soil in the group attempting to grow a legume. The silica content was higher in every case of manure treatment agreeing in general in this respect with the calcium content. The phosphorus showed the reverse in the case of the timothy and the rotation, but paralleled the calcium and silica with reference to manure for the continuous corn. The lowest phosphorus content in the humus extract occurred under corn given no manure. Manuring seems to have increased the calcium and silica contents in the extracted humus and raises the question whether the extra silica means merely more silica as ash from manure decay, or a contribution from the mineral fraction to the organic fraction by more interaction between the colloidal organic matter and the colloidal mineral matter of the soil.

The extracted humus reflects the soil treatments and follows trends in amounts and in composition as one might surmise their influence. The widest spreads occur between manure and no manure additions under continuous corn, for all the tested properties of the humus. The differences between these two soil treatments were less significant under timothy sod and even less so under rotation. Manure gave the humus with the highest content of nitrogen, with the narrower carbon-nitrogen ratio, and the larger total amount of humus in the soil. It also

gave the higher calcium content, and silica content to this extracted fraction. It suggested, however, the reverse relation for phosphorus.

Humus as a Possible Supply of Minerals for the Crop

If we were to assume that this humus is the sole supply of soil nitrogen to the growing plants and that, during the liberation of this nitrogen, the humus is broken down to liberate also its calcium and phosphorus, it is interesting to calculate the crop possibility in terms of calcium and phosphate so released. Taking the continuous corn plot without manure, as an illustration, of which the soil contained 3.2% humus, there would be 64,000 pounds of humus per acre, carrying 3.45% or 2208 pounds of nitrogen. This plot has been producing twenty bushels of corn per acre as an average requiring thirty pounds of nitrogen as an estimated figure. The release of this amount of nitrogen would break down 1.36% of the total humus in the soil. If at the same time, the calcium and phosphorus in this corresponding amount of humus were liberated, these amounts would be 18.4 pounds and 3.91 pounds, respectively, or the calcium needed for a corn yield of fifty bushels, and the phosphorus for twenty-five bushels, both of which are yields above that being produced per plot. If this is a correct assumption, then the organic matter or humus could supply not only the nitrogen, but the calcium and phosphorus needs of the crop as well.

Degree of Lignification of the Organic Matter

As an attempt at further differentiation of the nature of the organic matter in relation to soil treatment, tests were made of the degree of lignification according to the method suggested by Waksman.[2] By the treatment of the soil with seventy-two per cent sulfuric acid it is assumed that only those carbonaceous compounds approaching lignin remain unhydrolyzed and insoluble. The percentage of the organic matter found by this method to be in the lignin form is given in Table 1, which gives also the changes in total organic matter as based on the carbon.

There are no excessively wide differences in these lignin figures. The lowest percentage of this inactive fraction in the organic matter occurred where complete fertilizer had been applied heavily on continuous wheat. The highest percentage occurred where the sodium nitrate was used and has apparently been responsible for an organic matter that is highly lignified.

(2) Waksman, S. A. & Stevens, K. R. Soil Science 26 (1928) pp. 125-127.

Manure addition seems to have had an effect similar to that of nitrate additions.

These few determinations suggest that nitrogen additions alone, or manure with its high nitrogen content tend to give an organic matter of high lignin percentage and of a stable or less inactive nature, while under phosphate-potash fertilizers the organic matter remaining is much lower in this decay resistant fraction.

Variable Nitrification Activities as Related to Soil Treatments

Laboratory studies were undertaken to evaluate the nitrate accumulating capacities by these soils under different long continued cropping and soil treatments as a measure of the influence of these on the microbial behavior, within the soils. The samples were brought into the laboratory in late February, handled at optimum moisture into jelly tumblers, with treatments including lime and organic matter, and tested for their accumulated nitrate content at fortnightly intervals during ten to twelve weeks. Twenty-eight plots were included and the data assembled to include the effects of different cropping systems and rotations, and then for the different soil treatments including (*a*) manure, (*b*) superphosphate, (*c*) fertilizer, (*d*) ammonium sulfate, (*e*) sodium nitrate, and (*f*) limestone.

The nitrifying activity under all the soils with continuous crops was relatively low. The low level for corn, oats, wheat, and timothy or for all of these crops rather than a differentiation amongst them is the significant fact about the separate crop influence on this microbial soil process.

The rotations were not, however, without their influence. The nitrate accumulations were regularly higher for the three-year rotation, followed by the four-year and then in order by the six-year rotation. Except for the six-year rotation, they were higher in nitrate activity than the highest of the continuous crops, namely, timothy. Since clover occurred only once in each of these rotations, it suggests that the greater number of recurrences of this crop in the shortening of the rotation may be the reason for their taking their particular order in levels of nitrate accumulating activity.

The long continued soil treatments manifest their influences markedly on nitrate accumulating activities in the soil. The manured soils were especially responsive with nitrate production when limed in the laboratory, pointing out that these soils are not nitrifying their stock of organic matter rapidly because of

lime deficiency. That this effect by lime is not so much a matter of acidity as that of supplying calcium, is demonstrated by the influence of the superphosphate treatment. Soils, receiving superphosphate for twenty-five years, given nitrifiable organic materials in the test were almost as active in nitrate production as when given both lime and organic matter. Where the latter combined treatments produced 9.7 mgms. of nitrate, the former single addition gave 8.08 as the increase during six weeks of incubation. The higher general nitrate level by this phosphated soil when given something to nitrify was the distinguishing feature.

The effects by fertilizers were similar to those by phosphate as might be expected, since the latter is their main constituent.

In the plots treated with ammonium sulfate and sodium nitrate, the former has lowered the activity in the soil as a nitrifier. Lime additions were decidedly effective on nitrate production where ammonium sulfate had been used, though it was not without significant effect on soils treated with sodium nitrate, suggesting again the need of the soil for calcium. Where the field treatment of limestone had been used, the soil was at a lower nitrate level than where such had not been used. This was particularly noticeable by the failure of the soil to respond to liming in the laboratory in contrast to the marked response by the unlimed soils when given lime. However, the limed soil given something to nitrify was almost on a par in nitrate accumulation with the unlimed soil given both lime and green manure as laboratory treatments.

Table 4

NITRATE NITROGEN LEVELS IN SOILS UNDER DIFFERENT LABORATORY TREATMENTS AS INFLUENCED BY THE PAST HISTORY OF CROPPING AND SOIL TREATMENTS. (SOILS FROM SANBORN FIELD)

Cropping History and Field Treatment		(Pounds Nitrogen per Acre) Laboratory Treatments					
		No Treatment	Limestone	Organic Matter	Lime & Organic Matter	Mean of All Treatment	Increase over Lowest Item
Continuous Crops	Corn	25	83	55	122	71	—
	Oats	30	26	121	190	92	21
	Wheat	59	102	52	172	96	25
	Timothy	48	104	110	183	111	40
Rotation	Six-year	34	52	74	176	84	—
	Four-year	56	75	109	208	112	28
	Three-year	44	97	182	219	135	51
Soil Treatments	None	40	61	92	179	93	—
	Manure	49	93	120	196	114	21
	Phosphate	50	106	184	282	155	62
	Fertilizers	43	94	149	222	127	34
	Ammonium Sulfate	60	113	150	193	129	36
	Sodium Nitrate	62	87	174	216	134	41
	Lime	36	74	223	267	150	57

The general levels of biological activities as demonstrated by nitrate accumulation in these soils can be measured from the data in Table 4, giving the average nitrate contents during ten weeks of laboratory study and particularly the mean of all treatments.

Summary

From these various observations of the organic matter in the soils under different treatments on Sanborn Field it is evident that there are wide differences in the biological activities now after fifty years. Where the organic matter remains at a relatively high level it has failed to be consumed by the microorganisms very probably because of its deficiencies as a bacterial ration. Some of the deficiencies suggested are (*a*) nitrogen, (*b*) calcium, (*c*) phosphates, and possibly (*d*) potassium in the mobile forms to serve in the nutrition of the microorganisms. Where these have been added as soil treatments, the total supply of organic matter has been reduced. The increased crop returns, running parallel with organic matter reduction in the soil, suggest strongly that where the organic matter fraction of the soil is not breaking down, it is being retained at modest levels because these mineral elements are too deficient in the soil for the microbiological processes. They are then consequently deficient in the soil for the plants' activity on a high level. Such conditions suggest that when these deficient nutrient items are delivered by the soil to the plant, they may come in the main from the more slow decay of the more stable organic matter.

FROM MISSOURI

Readers of BIO-DYNAMICS will remember Helen Philbrick's account of her own and her husband's homesteading experiences, which appeared in the Winter 1949 issue under the title of "Faith Homestead". The following bits come out of their most recent work in the Roanridge Rural Training Foundation, which consists in part, not only of feeding the students, but also building up a demonstration for them to work in and observe.

They came East last Fall for conferences and such, with their New York office, which were so demanding that they were

not able to visit any of their bio-dynamic friends except for a brief stop with Ruth Eastman on their way here.

"We had a wonderful time browsing through her garden. She gave us three plants: thyme, valerian and horehound. When we got the horehound plant back to Missouri, we matched it up with one lone green plant still standing in the pigs' pasture next door—and it is the same. Evidently pigs don't like horehound, but the sheep have nibbled the plants they could reach through their fence."

The demonstration homestead is part of a large farm and this explains the presence of the pig and sheep neighbors.

"So far we have no animals of our own yet, although we're ready now to commence negotiations for both goats and hens.

"The garden this year was a great success. We raised vegetables enough for 30 people for ten weeks in a garden much less than 80 feet square. The BD compost plus this wonderful Missouri topsoil, and a good distribution of rainfall all contributed.

"I did want to write you about our experience with the beets last summer. We planted seeds in flats in the greenhouse early in the spring and later transplanted them into 3 inch pots. (The greenhouse spoken of belongs to the College of Agriculture and they have the use of a corner of it. Ed.) As soon as we could get them outdoors, we planted them in the garden, and we had beets the latter part of June for the students. However, we didn't use them all that early and several grew on until August and reached a diameter of five, six, even seven inches and of course, we expected them to be hard and woody. They weren't. By the end of the summer it would take three or four beets to feed our students, and they were still delicious! (These beets sound like Winter Keepers to the editors, although the lady didn't say.)

"Most of our herbs came along well although the plants that came from a herb garden in Washington were badly infested with different assorted pests—so we nursed them along. Here's some more Bio-Dynamic News! The rosemary seeds that Ruth Eastman gave me—still in the seed pods—germinated and were up in four days, while the rosemary seeds we bought from a herb grower and from a wholesale seed store are not up yet—and won't be after all this time. Another score for BD."

(This last part about the herbs was written on December 6th. Ed.)

IMPRESSIONS OF AGRICULTURE IN ENGLAND AND SCOTLAND — 1950

EHRENFRIED PFEIFFER

Every inch of soil in England and Scotland was used for food production during the war years. Subsequently, even today, most of the land is still under cultivation, with the emphasis on grains, potatoes, and protein crops (legumes). The system of short 'leys' has become general practice. (A 'ley' refers to putting land into pasture or hay, and short or long thus mean temporary or permanent in American terms.) The visitor who has not seen this country for more than ten years, misses many pasture and park areas which formerly gave the landscape its familiar character. The arable land use is now almost as intensive as on the continent (except for the really submarginal soils).

The reforestation of submarginal lands, in addition, as protection against erosion on exposed hillsides, has also made progress. It was a pleasure to see such a project as the one on the farm of Rolf Gardiner at Springhead, Fontmell Magna near Shaftesbury, Dorset. These hillsides were last viewed by the writer fifteen years ago. Now they are covered with a mixed forest which already needs to be thinned, needs selective cutting. A thick layer of humus teeming with soil life and earthworms has formed where once was a soil one might have called "baldheaded". Sir George Stapledon and his wife were also present during my visit to Mr. Gardiner's farm. We had an interesting discussion about the underlying principles of short leys, agreeing that a four-year ley would really build up a soil and produce good humus, while two years would not be long enough to give the land a real "rest".

It was during this visit that we also saw a large farm which has been managed for thirty years or more with mineral fertilizer and cover crops, without showing any of the much-quoted diseases or other handicaps of mineral fertilizer applications. It is good to see such things for the modern, commercial farmer will always use them as examples when arguing with the organic enthusiast. There was nothing wrong with these soils; they were high in organic matter, in earthworms, and tops in crops. They were not the best soils by nature, consisting of a shallow layer of clay over limestone. A favorable cool climate with plenty of moisture evenly distributed throughout the whole year

helped to maintain a balance, which was otherwise supported by the plowing under of massive amounts of cover crops.

The owner of the place reasoned that he needed such bulky cover crops and therefore applied lots of fertilizer in order to grow them. A good balance in the rotation of clean-cultivated crops and green crops also helped to maintain the soil structure. This man went as far to the mineral extreme as one can go and still maintain the humus content with plowed under green manure. The potato harvest was excellent in both quantity and quality. The history of the crops, as far as feeding value and livestock health are concerned, could not be followed, since no breeding cattle were raised there, and the large dairy herd was used only for high production—all cows were liquidated as soon as troubles showed up. This, of course, is not in conformity with the organic theory and obscures the picture. We also found that too much experimenting with new varieties of seed was done, probably due to the fact that they did not last long enough. (This last, however, is the writer's personal opinion only.) Only seeds grown from seeds, grown from seeds, etc.; livestock raised from livestock, raised from livestock, etc.; both grown and raised with the same method for a long time will finally decide which method is truly "conserving". No short-term experiment will ever give the full answer.

Our organic enthusiasts should always remember that there is also evidence in support of the opposition. But both sides should learn to evaluate the factors which lead to the preservation of the species, the maintenance of seed vitality, to the reduction rather than the increase of sprays (the latter being a disease symptom rather than an indication of progress), the maintenance of health, the absence of sterility, abortion and other diseases in livestock, etc.

Lady Eve Balfour's new experiment at New Bells Farm, Haughley, Suffolk, under the auspices of the Soil Association, is meant as a demonstration in support of the organic method. Three farms are kept under strict control (all three have dairy herds) ; one is completely and exclusively organic, the other inorganic, the third unit uses both methods blended together. The experiment has not been under way long enough to draw conclusions from it, though it seemed to the eye of the visitor that the mixed unit made the best showing. Only after many years of continuous controlled management will it be possible to see which method will survive in the long run. Lady Balfour de-

serves the highest praise for her painstaking and energetic leadership in this endeavor. It is courageous and costly to carry out such experiments on a large scale without government support. Of course, were the equivalent of the cost of but ONE day of war earmarked for such projects, many problems could easily be solved and answers given to such questions as those of the relationship of soil fertility to health or the problem of cancer. In a country which suffered as much as England did from the war, still visibly struggling with the after effects of the war, the objectivity of the New Bells Farm experiment merits wholehearted commendation.

A visit to the farm of Mr. J. E. Hosking near Charing, Kent, gave this reporter some striking additions to his previous knowledge of intense land use. Here, on 15 acres of temporary pasture, 22 Jersey cows were pastured all day during the growing season, in rotation on half-acre lots. The rotation was controlled by an intricate but efficient system of electric fencing. This was certainly the highest intensity of pasturing ever seen by this writer. What about milk production? It was A-1. Of course, here again, a favorable climate with evenly distributed rains supported the system. Nevertheless, it shows what can be done and achieved under favorable conditions with an intensive pasture rotation. This farm was run all along organic lines. Everything was really tops, just as it was on the above-described mineral cover-crop combine, the main difference being that here tremendous fertilizer expense could be saved. The story that one cannot grow crops without fertilizer was repudiated by facts on this as well as other bio-dynamic and organic farms.

The bio-dynamic center in Clent, under the leadership of Dr. C. A. Mier as consultant, and Mr. David S. Clement on his own farm, have done valuable work in the spreading and practice of the bio-dynamic method. This reporter was particularly impressed by Mr. Clement's skillful management. Here is a farm which in due time will become a model for bio-dynamic management on a large scale.

Another interesting demonstration visited was at Blandford Camp in Dorset, where they are working, at the instigation of Mr. Rolf Gardiner, on the problem of the fermentation and composting of straw with sewage sludge. Many bio-dynamic farmers and gardeners shun the thought of using sewage sludge, basing their dislike of it on a remark of Dr. Steiner's that

night soil should not be used for vegetable gardens, or if used should first undergo at least four years of fermentation. For reasons of health and sanitation, Dr. Steiner's statement can be fullheartedly endorsed. The problem, however, still remains: What are we going to do with the increase and accumulation of sludge? This is a problem which causes ever mounting concern. The sewage cannot be allowed to flow down the rivers or to accumulate on the seashore, beaches, and in the bays.

The writer has given this situation much thought and come to a conclusion which might be called a compromise: Sludge should also be treated, mixed with other composting materials and turned into a well "seasoned" compost.

If let into the streams and rivers, it will gradually destroy the "self-clearing" action of the rivers. A sewage process is all right and sludge can be used, if the water draining away and the sludge itself no longer contain any intestinal or fecal bacteria —B. coli, for example. The sludge itself is not ready for agricultural or garden use. It does, of course, grow crops. But it has been observed that green vegetables grow into bulk, the soil cakes easily, and burns have been noted on dry soils. The typical aerobic process of fermentation which maintains soil life and produces digested humus, is missing. A second fermentation of said sludge is necessary in order to stimulate the soil-bacteria type of aerobic fermentation. Here shredded straw or other organic wastes, such as leaf mold, sawdust, or spent hops, come in handy. These materials should be shredded to increase their absorptive power, bring about aeration and facilitate handling. Until there can no longer be any possibility of the continued presence of fecal or pathological bacteria we recommend that such composted sludge be used *only* for crops which do not return directly to the kitchen and the human mouth, that is, for orchards, lawns, golf courses, flower gardens, field corn and sugar beets, possibly for pastures, but not for vegetables.

One of the most interesting things observed at the Blandford Camp demonstration was the fact that the filter beds were penetrated through and through by the red (manure) type of earthworms. Evidently the worms produced a particularly "fine" kind of fermentation and cleansing, for the sanitation officer in charge reported that the water filtering out was purer than that of wells and springs in the area. He also told us that he adds cow manure to a filter bed when it begins to fail, thus restoring the vigor of the earthworm action. To this reporter's

mind such observations are of extreme importance. Problems are here to be licked, not simply ignored for orthodox reasons. In our laboratory we have a sample of a compost made from 80% human excrement plus 20% earth, treated with the B. D. Compost Starter. This sample looks and smells like earth, does not contain any fecal bacteria, in fact contains about the same microflora as is in earthworm castings. There is hope that the problem can be solved.

In Scotland, a visit was paid to Lord Glentaner's farm, Westhall, near Oyne, Aberdeenshire. This place is operated by Mr. D. J. Duffy. Here, land has been reclaimed and improved in production by an intensive system of crop rotation, using forage crop mixtures of oats, barley, broad beans and peas. The stand of these crops was remarkable. These fields really showed what the bio-dynamic treatment of manures and soils can do in the production of masses of green forage, under the moist, cool climatic conditions of the area. (The yield was estimated at 20 tons per acre.) A local expert and farm appraiser, who had seen this farm four years ago, commented on the improvements and confirmed my impressions.

Mr. Duffy has also introduced an intensive use of pasture land, allowing hogs and chickens to run on the same range. The small poultry houses, which are on skids, are moved from one location to another so that all parts of the pasture in question benefit from the scratching of the birds, which aerates the soil. As long as a pasture is rich enough—and this was the case here—there is no danger of either hogs or chickens tearing up the sod. In fact, the sod cover was in perfect condition. In the autumn, the hogs are allowed to root up the sods. They enjoy this natural activity and at the same time do the plowing for Mr. Duffy; in the end, leaving a well-manured field ready to enter the cultivated crop rotation. Neighboring farmers, I am sure, must have thought this was a crazy idea, but the results under the specific soil and climatic conditions of Aberdeenshire have certainly justified the practice.

Other items of interest at Westhall were a well-managed vegetable and flower garden. In general, we found that the English and Scotch farmer is well versed in economy—sometimes even more calculating than the average American farmer. Yet we saw beautiful flower gardens almost everywhere, and the question arose as to whether such gardens are not a pretty expensive hobby. These men were asked: How can you afford to

spend so much time on a flower garden in view of all the difficulties of a post-war economy? And all of these canny, practical farmers defended the idea that flowers (besides their value for bees) have a beneficial biological influence. They insisted that their farms would lack something were not the purely economic aspect balanced by the beauty of the flowers. This is where they rest their eyes after a hard day's work (television has not yet come into the lives of these farmers) and receive new inspiration for the next day's tasks. The idea, 'grow your own food and be healthy', has reached into the realm of beauty and become: 'raise your own flowers and live in beautiful surroundings'. It is felt that this adds moral strength to the homestead and is, therefore, worth the trouble.

We were also shown a garden plot where Mr. Duffy tried to reach the limit in crop mixtures in order to demonstrate how far one can go in intensity of land use. "This is my inspiration lot", he explained, "from which I get ideas for more and better rotations and mixtures in field crops too." There is no doubt that the intensity of growth on a soil rich in organic matter, with biodynamic treatment, can reach a density which is limited only by the fact that plants have to grow side by side and cannot penetrate one another. There was a potato patch, where potatoes were growing on pure compost in 'tiers' against a wall. These vines looked perfectly healthy, were six feet tall—in fact, this plot looked more like a jungle than a potato patch. While such a system may not be practical for Maine and Long Island it does demonstrate two things: first, that it is possible to grow healthy potato plants, free from nematodes; second, that organic soils and compost do not decrease yields if properly managed.

Another pleasant feature of this garden was the strawberry barrel, a quite rare sight in the United States. As most small gardeners and homesteaders will know, this is a wooden barrel with 2 to 4 inch holes bored at intervals around the sides; the barrel is filled with good earth and strawberry plants set in the holes and in the top. Here, the barrel had been filled with compost and everbearing plants had been used. When we were there the whole was covered with strawberries.

Wherever visits were made in both England and Scotland, it was also possible to gather local farmers and gardeners together for meetings and lectures. All of the discussions were most fruitful and many new ideas and practices were investigated. Compared with the continent, English and Scotch farms are

more fully equipped with mechanical devices, but not as completely as American farms. This writer envied them their electrically heated steam sterilizers for milking utensils. Needless to say that we do not have them here as yet. They would be such a help in the milk house, eliminating many, if not all, of the washings and rinsings we have to carry out with HTH and other chemical compounds. Silos are still very scarce, but a lot of silage is made in trenches. Very little corn (maize) is grown, but the most common forage mixture is the one mentioned in the report of the visit to Lord Glentaner's farm. The same mixture or a similar one, might do well in cool, moist sections of the U. S.

The trip ended with lectures and discussions with our biodynamic organizations, and a public address to more than 600 people in Caxton Hall, presided over by Mr. Rolf Gardiner, the Earl of Portsmouth, and Lady Eve Balfour.

BRIEF DIRECTIONS FOR THE USE OF THE BIO-DYNAMIC SPRAYS

For details of how and why, see leaflet "Bio-Dynamic Sprays", 15c; also articles in Bio-Dynamics—Spring 1950 (Spray 500), Summer 1950 (Spray 501), Autumn 1950 (Spray 508 and 507).

SPRAY 500—for use on soil.

Keep moist until used.

Part portions may be used, keeping same proportions and stirring full time each.

Spray only on areas previously fertilized with manure or compost prepared with preparations 502 to 507.

TIME—Shortly before seed sowing or transplanting.
Mainly in spring or fall.
During the latter part of the day.
When there is no wind.
Preferably on an overcast day.
When the soil contains some moisture—never in drought.
Never just before a rain.

USE—One portion of 500 to 3 gal. lukewarm water.
Rain or other water not contaminated with chemicals.
A clean container large enough to prevent splashing out—*no* chemical residues.
A light-weight, but strong, stick—discover by experience what length you like.

STIR—*Vigorously* in one direction until liquid forms a deep crater.
Quickly reverse direction and repeat.
Continue this alternation every minute or so for *one full hour.*
Preferably using direct from the shoulder motion, not just wrist motion.
Preferably changing hands with each reversal.

SPRAY—As soon as possible after stirring—it deteriorates rapidly with standing and if left overnight is useless.
With *clean* utensils—chemical residues makes 500 useless.
With ordinary sprayer (will need straining first)—or for small areas, a bucket and whisk broom.
Covering 1 acre of ground with this amount.
If possible on soil that has been recently worked.

If possible raking lightly afterwards.

If on area where 500 has been used before, quantities may be more *dilute,* increasingly so with each application.

SPRAY 501—for use on foliage.

Keep in any dry or sunny place until used. Keeps indefinitely if dry.

Spray only on area where 500 has been used previously.

TIME—Only after plant roots are well established.

Never before transplanting.

As early in the morning as possible.

When there is no wind.

Usually in late spring or early summer when warm weather is well established.

Never when there is danger of frost.

Never just before a rain.

With seedlings—when second or third leaves have unfolded.

With trees—not until they are of bearing age.

Never on young evergreens or fruit trees.

In foliage emergencies—when diseases or pests have destroyed much foliage.

Only following blossoms on trees or shrubs where these come before leaves.

Especially during wet seasons with too little sunshine.

Indoors or in greenhouses—during shortest days of the year especially.

USE—Same as for 500.

STIR—Same as for 500.

SPRAY—Promptly as for 500.

On foliage—but will do no harm to soil.

With clean utensils as for 500.

In a fine *mist* spray—making sprayer necessary for this.

Covering about an acre with one portion.

SPRAY 508—for use on foliage.

Keep dry and in darkness until needed.

Part portions may be cooked, keeping same proportions.

Fully effective only when used following other Bio-Dynamic preparations.

TIME—During wet, damp or sunless warm weather as preventive of or cure for fungus diseases.
Only during warm time of year.
Usually at two week intervals, oftener in emergency.
When there is no wind.
Not when a rain will soon wash it off.

USE—1 portion 508 to 1 quart water—for cooking.
1 gal. water for later dilution.
Same stirring equipment as for 500.

PREPARE—By cooking slowly in covered vessel for 20 minutes.
Strain and dilute.
Stir as for 500 but *only for 15 minutes.*

SPRAY—With clean sprayer as for 501.
Using fine mist spray.
Within a few days when once cooked and diluted.
Gradually more dilute the more frequently it is used.

EARTHWORMS REJUVENATE THE SOIL

LAWRENCE C. LEMMON

This interesting account of Mr. Lemmon's experiences with earthworms and his general thoughts on conservation, first appeared in the SCIENCE COUNSELOR, Vol. XIII, No. 2, June 1950. Published by the Duquesne University Press.

The author writes out of a wide background of experience. He is a graduate landscape architect, has studied under Frank Lloyd Wright, worked in nurseries and in the National Park Service, the U. S. Forest Service, etc. Besides all his earthworm activity, he is, at present, employed as a Landscape Architect. Last but not least, he is an active member of the B.D. Association.

* * *

When the first settlers came to these shores they were confronted with Nature's bounty in all its primeval abundance. Timber was wantonly cut and burned to make clearings for field crops. As soon as the soil was broken, erosion set in, and in the space of a generation the once rich soil was played out and had to be abandoned. The country was young, and there was always more land to the west to be had for the taking.

A few far-sighted persons, such as George Washington, observed what was happening with misgiving, but for the most part the ever increasing population gave no thought to the future of this great new country. As a result, one of the most inglorious aspects of our history is the story of how we, as a people, squandered and destroyed the greatest natural heritage that ever blessed a young nation at its birth.

Because of this thoughtlessness, we of the present generation must come face to face with stark reality. Our forests have dwindled to a point where they are inadequate to meet our everyday needs. We now have to import forest products. Our rivers and streams are so loaded with mud and pollution that they no longer support the abundance of fish once found in their waters. They alternate between flood and drought, causing great expense and misery. Our fields have steadily become less productive. We try to bolster the yield of our sick and dying soil by the addition of chemical fertilizers. For a while this offered some hope; then we discovered that to be effective the quantity of these chemicals must be increased annually. The soil becomes more lifeless each succeeding year, and finally has to be abandoned.

What is the answer? Is desolation to be the fate of this great land? Is there no other course for intelligent men?

I believe there is, and I believe that this generation is beginning to find it.

We now turn to Nature and discover that new soil can be made. Nature takes many centuries to lay down one inch of fertile top soil, but man can in the space of a few years produce several inches of rich topsoil from subsoil which would scarcely support the scrubbiest weeds. We like to refer to the process by which this is done as *Nature's law of return.*

Instead of burning, or flushing our wastes into our rivers, we now return them to the soil whence they sprang. Here the earthworms, bacteria, fungi, and many other forms of life, encouraged to return to the soil by the presence of their natural food, waste organic matter, feed upon it and digest it, creating an end-product *humus.* During this digestive process minute quantities of carbonic acid are released in the soil. This acid etches the minerals from the grains of sand and the particles of clay so that once again the soil contains in soluble form all the ingredients needed by the plant roots. A more abundant crop is the result. When all of this crop is returned to the soil, either directly or indirectly, an ever increasing supply of organic matter is available for soil life to feed upon. This means more plant food each succeeding year; in other words, more topsoil.

Since the success or failure of any landscape planting is to a great extent dependent upon the health and vigor of the soil, I quite early became interested in soil and soil health. It is futile to plant healthy plants in cold, lifeless soil. Soon such plants will sicken and be subject to the inroads of insect pests.

In February, 1944, I purchased a new suburban home in Arlington, Virginia. The house was delightful, all that we were looking for, but the red Virginia subsoil which surrounded it was only what the builder had excavated in making a basement. Here was a challenge and an opportunity to try some of the theories I had in mind. My wife was as anxious as I to do something about improving this soil. So, even before we were completely established indoors, we were breasting the March winds and freezing our finger tips setting out trees and berry bushes.

Since we began this venture during the war years, we hoped to have the little plot of ground produce the greatest abundance possible. Instead of ornamentals, we went in for fruiting trees and shrubs and all the garden vegetables that could be crowded

into the available area. As a result of this activity every square foot of our soil was turned over. Not a single earthworm was found! This fact alone was a pretty good indication that the soil was dead.

Trees, shrubs, and garden vegetables all got off to a rather poor start. However, I believed that were I to mulch everything heavily with straw, soil water would be conserved and possibly soil life might be induced to return. A mulch of straw several inches deep when compacted was the wonder of all our neighbors. Who had ever heard of a row of beans with a summer mulch! But this deep mulching was to pay off. Our soil began to respond to the treatment, and we had some food from the area the first year.

In the fall we collected several tons of leaves and from them made a compost of sorts. A winter cover crop was planted which was to be turned under in the spring along with the partially broken down leaves which had been composted. The soil was beginning to show slight signs of improvement and this encouraged us. A new crop went into the ground and again a heavy mulch was laid down. This second year our garden was entered in the Washington Victory Garden contest. It won second place for Arlington County.

We then came upon a story of how a man in California nad made a remarkable improvement in a piece of desert land by introducing the earthworm in abundance. We purchased $40.00 worth of the worms and read everything we could about their habits and culture. In a few months our investment had increased, because of the remarkable fecundity of this worm, to an estimated worth of several hundred dollars. Now we were ready to take a part of this horde from the culture boxes and place them in the garden and under our trees and shrubs. The straw mulch began to disappear more rapidly and had to be replenished several times during the growing season. The abundance and vigor of our growing things began to reflect the improvement which was taking place in the soil.

As we were doing without chemical fertilizers, the next logical step was to discontinue the use of all chemical dusts and sprays. We knew that nature used no such things, and we felt that as the health of the soil was restored the health of our plants would grow apace. We reasoned that a healthy, well nourished plant must have its own protective characteristics. Anyway, we were going to give the matter a trial.

We had begun raising worms in lug boxes in our basement. From time to time we placed part of our increase in the soil about our trees and shrubs and wherever we had anything growing. Before long we had worms in ever increasing numbers indoors and out. As these worms more than double their number every thirty days, we soon had our basement filled with lug boxes in spite of the fact that we had begun to sell worms to other gardeners. At one time we were caring for nearly one hundred boxes filled with worms with the prospect of that number's doubling within the next thirty days. The whole thing was getting just too big to handle. To solve the problem we decided to transfer all our worms to large compost pits out of doors. This move made it much easier to care for several million worms. The demand for the worms has increased each year, and the outdoor pits proved to be the right answer for the practical production of large quantities of worms.

The earthworm is one of Nature's scavengers. His natural food is dead plant and animal refuse, as well as small particles of the mineral soil through which he moves in his burrowing. Matter such as dead leaves, grasses, straw, weeds, table refuse, etc., all types of animal manure, clay and sand are taken into the gizzard of the earthworm and mixed with its digestive juices. The worm is nourished, and the refuse of digestion along with other body wastes is passed off as castings. These castings are humus in its pure state. Upon analysis the castings are shown to contain in soluble form very large percentages of nitrogen, potassium, phosphate and calcium, as well as many of the trace elements. Thus it would appear that chemical fertilizers are unnecessary where there is an abundance of waste matter and plenty of worms to change it to humus.

The water-retaining quality of castings is remarkable. Laboratory tests have shown that they will retain two and one-half times their own weight of water. This fact alone, as was indicated by the experiments of Dr. Hopp of the United States Department of Agriculture, Soil Conservation Service, means that where there is a large earthworm population, soil erosion is slowed up considerably. Rain water, instead of running off and causing trouble, will be absorbed by the soil and given up much more slowly, thus helping to obviate the double curse of flood and drought.

Upon analysis, it was found that earthworm castings contain a count of over 12 billion aerobic bacteria per gram. For

comparison, fertile soil has up to five hundred million. When all these factors are considered, one can readily see how a cold, lifeless, mineral soil which cakes over after every rain can be completely transformed by introducing earthworms under a heavy mulch of leaves and the waste which the average householder usually destroys by burning.

When we took over in the spring of 1944, we hit upon the idea of keeping a sample of the soil from our garden each year to have a visible record of what progress, if any, we might be able to make in transforming subsoil into rich topsoil. Our success in this venture is now a matter of record. It is indicated by the many complimentary things that have been written about us by local and national newspapers and magazines. As a result of this venture we now carry on correspondence with folks all over the world who are anxious to improve their own soil. Our own garden has become a show place where visitors are always welcome.

We still have some insect pests, but they do very little damage in spite of the fact that for five years we have not used a bit of insecticide. Our plants are now so vigorous and healthy that they are well able to take care of themselves. Perhaps these so-called pests are nature's monitors whose duty it is to keep the race of plants strong and vigorous by eliminating the weaklings. The cucumber beetle is probably as old as the cucumber vine. If the vine under Nature's care had succumbed as readily as it sometimes does in our modern gardens, it would very early have been eliminated from the race. It was not eliminated; so there must have been a reason. We believe that the reason lay in the soil in which the plant grew. The soil was in good health, therefore the plant which grew in it was a healthy plant.

When Peter Henderson, the founder of the great seed house which bears his name, was growing garden vegetables on Long Island for the New York market more than a hundred years ago, he found time to write a gardener's manual. This manual, which discusses the problems of the professional gardener of that time, gives very little notice to insect pects. The obvious conclusion is that garden insects were not the pests they are today. The soil was nearer to its virgin state and could produce strong healthy plants.

We believe that if all matter were returned to the soil, either by proper composting or by mulching, and if earthworms were introduced to break this waste down into rich humus, bacteria

and other forms of soil life would again return. In a few years our soil would be healthy and able to support healthy plants, which in turn would support healthy men and animals.*

We believe that this procedure along with other conservationist practices, such as reforestation, river and stream clean-up programs, contour plowing, strip planting, and the elimination of one-crop agriculture, will go a long way toward protecting our natural heritage, and enable us to give a good accounting to our children for the years of our husbandry.

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*It has been the experience of many users of the bio-dynamic method, including the editors, that the use of b.d. composting and b.d. preparations is a very efficient way not only of breaking waste down into humus but also of luring a natural earthworm population into the heaps and the environment.

What Is The Matter With Your Soil, by G. D. Scarseth in the magazine Better Crops with Plant Food:

"Clover failures were rare in Indiana 40 years ago but now are frequent. One of the causes for this is associated with a loss of the original surface, particularly the organic matter and basic nutrients . . . In the warm regions of the South, where the rainfall is high . . . the native nitrogen supply is lost in a few years of farming . . . In areas of scanty rainfall during the growing season and with medium heavy soils, it is best to plow under the nitrogen carriers."

The problem (of nitrogen losses) is relatively simple—either more nitrogen-fixing plants (legumes) must be grown and returned to the soil, or nitrogen-carrying fertilizers must be used . . .

"When an ammonia carrier is plowed under with organic matter, a condition in the soil develops that tends to keep the ammonia from nitrifying rapidly to nitrates (meaning that no rapid losses occur in the presence of organic matter) . . . Since plants can use nitrogen in the ammonia form as well as in the nitrate form, none of the availability of the nitrogen is lost, but much is gained, for the ammonia particle (ion) is temporarily held by the clay particle (and the colloidal humus, Ed.) firmly enough to retard it from moving easily in the soil water . . .

"In dry weather the movement of nitrates is upward, and they often accumulate at the surface above the root zone of the plants. Some plants are often starved for nitrates because of this movement. Then, too, in dry weather, top-dressings of nitrogenous fertilizers are ineffective, because they will remain on the surface . . .

"When plant matter decomposes to form humus in the soil, the humate part of the organic matter will push the fixed phosphate-ion off the clay and leave it in an available form. The humate-ion will attach itself to the clay where the phosphate-ion had been fixed. In this manner organic matter aids the more favorable behavior of phosphates in soils that are acid between pH 5.0-6.0." Organic matter also "converts phosphates into forms available to plants even in alkaline soils.

"A virgin soil (i.e., one containing a high amount of humus, Ed.) is usually rich in available (exchangeable) potash because, besides the clay particles to hold potash, black organic matter will also hold potash for plants . . .

"The losses sustained by crop removal are great enough to exhaust most soils in a period of a few years, particularly if the crop residues or manures are not conserved and returned. Even with manures returned, the potash losses will be great, because much of the liquid of manures and animal excrement naturally rich in potash is lost. The amount of potash in the urine excreted by a cow in one year has been estimated to be equal to two 100 pound bags of muriate of potash."

(Here is where the manuring and conservation practices of the bio-dynamic method, and a liquid manure tank as well, can be truly of help on a farm. Ed.)

Orange Fruit Size, by I. C. Johnston in California Agriculture, Vol. 4, No. 11, November 1950:

Two outstanding causes of small fruit size in oranges are poor physical conditions of the soil and inadequate irrigation.

Trees producing large fruit were larger, darker green, the foliage more dense, and their roots were more widely distributed and in better health.

Scaly bark and gummosis did not affect fruit size.

No benefit came from cover crops. The small-size group had more and heavier cover crops than the large-size group. Nitrogen fertilizer did not influence the size. More phosphorus and potash were used by growers in the small-size group than in the large-size group. Large size and high yield went together.

The physical condition of the soil seemed to be an important factor, not so much the depth of the soil or the type. Light and medium soils predominated in the large-sized Valencia group. Navel oranges on light soils produced small oranges. Inadequate moisture supply and low water-holding capacity of the soil, as well as higher soil temperatures, seemed to be decisive factors. The physical condition of the soil is very important. Plow-sole, compactness of the soil and general tilth have to be considered. The small-size group included 3¼ times as many orchards on soils which have pronounced plow-sole and compactness as did the large-size group. The tilth of the soil was classed as poor in four times as many orchards in the small group as in the large-size group. The small-sized group was tilled more often and to a greater depth than the large-sized group.

Irrigation appears to be the most important factor in fruit size. Inadequate irrigation is often caused by poor physical conditions of soils which restrict root and water penetration. These results do not necessarily mean a need for more irrigation.

(With as thorough a survey as this, one wonders why the beneficial influence of humus upon tilth, soil structure, water-holding capacity, and root development was not investigated. Ed.)

Waters Overpumped, Farmers Warned, from the California Citrograph, Vol. 34, No. 10, Page 455, August 1949:

"The San Joaquim Valley's underground water supply is being overpumped by an estimated 1,000,000 acre feet each year, and water tables are dropping alarmingly."

In enlargement of this statement, Irving Ingerson, Senior State Hydraulic Engineer, also declared (at a meeting in Bakersfield) that in the past 20 years more than 30,000 irrigation wells have been sunk in the San Joaquim Valley, at a total cost of approximately $168,000,000. The present overdraft of underground water, he warned, is "beyond any normal and natural amount of replenishment."

STRESSING THOROUGHNESS

PAUL PFUND

Farmers and gardeners who have attended Bio-Dynamic Summer Conferences in recent years will certainly recall the author, and his contagious enthusiasm for the organic approach. Here Mr. Pfund, a resident of Elmhurst, Illinois, presents something of a horticultural autobiography, telling of his present work and recalling his early training, beginning at the age of eight, by his thorough, horticulturally expert Swiss-born parents.

* * *

Recently I was asked if I would contribute something in the form of a human interest story for Bio-Dynamics. I consented, so here is the attempt. My hope is that it may help perhaps, even if feebly, to substantiate the magnificent efforts and accomplishments of my esteemed friend and counselor, Dr. E. E. Pfeiffer.

His loyal devotion in constantly bringing before his fellowmen the profundity and all embracing importance of a soundly biological soil husbandry is of immeasurable value.

I have found in him an embodiment of rare soundness of purpose, coupled with a keen understanding of present day soil problems. This could be born only of deep and abiding convictions and developed through many years of ceaseless research in his chosen field. Such sterling qualities it seems to me are rare indeed in these days. To me they are incomparably far-reaching, most creative, and constructive.

This same high purpose was most outstanding in my parents, natives of Switzerland, in all of their activities and by no means overlooked when it came to soil culture. Both of them were expertly trained horticulturists. Switzerland, in my opinion, is one of the noblest of all nations. My admiration for these sturdy self-reliant people runs high, wide, and deep. Through two world wars this little country has been the haven for battle weary souls. Tenacity, perhaps born of their topographical ruggedness, has served the Swiss exceedingly well for centuries. They mind their own business most admirably and if invited to do so could help some others to learn to mind theirs. Of all nations they are militarily best prepared; have always been. Yet they have had no wars for hundreds of years. Corruption from outside gains no foothold and crookedness within is nipped in the bud. Whatever their inconsistencies and weaknesses may be,

I believe it remains for any nation on the face of the earth to produce a more peaceable record than Switzerland has written in her long history. Others at her borders lie largely in ashes today. Why the difference? I think it is primarily because of their habitual thoroughness, consistency, and integrity, that the Swiss are so outstanding. May they ever be so. Now why all this eulogy about so small a country? Just to bring into focus the immeasurable importance of being consistently thorough as an abiding life principle.

I was much intrigued by my father's persistence in composting: the conservation of all suitable materials. My first impression of its incalculable value was received at the age of eight when father gave me the first major lesson. He was well qualified for this with his years of strenuous apprenticeship in his native Switzerland as well as France and Italy. He made no attempt to deal academically with horticulture, but his empirical methods did produce results in an exceptionally direct manner. As applied to commercial operations, I have seen nothing to surpass them. Such, then, is my background and I have long since been convinced through over fifty years of successful commercial horticulture under glass as well as outdoors, including five years of intense research in Florida, that the laws of nature are indeed inviolate.

Our operations through the years interestingly enough included some farming and animal husbandry, as well as vegetable and fruit growing, and a considerable amount of landscape gardening in which a large measure of effort and ability was applied to landscape architecture. However, underlying all this was a soundly biological soil culture.

In those earlier years of course, no question was raised concerning soil bacteria and all of the other highly technical questions of today. We were essentially dealing with virgin soil. Countless acres of lush bluegrass prairies stretched in nearly all directions. Fertility offered itself lavishly. Much of the problem of today was unknown. All of this, to put it simply, is quite a measuring rod, or standard, if you please, which I use in these times.

I know it sounds historic to state that I was taught contour plowing fifty years ago on a rugged clay farm in Indiana, made up largely of ravines which had then already become seriously eroded through careless management. In two years this condition was changed into lush bluegrass meadows and remained

thus until recent years when the price of corn became so lucrative as to induce the then owner to plow the hillsides again in a haphazard way with the resultant return of gullies and erosion.

It can be well understood how one could become a confirmed believer in the inviolate principle of compost making, nature's process. Through the years I have tenaciously adhered to this principle with ever better results in exact proportion to which it has been complied with.

Not from the standpoint of boasting, but rather from the position of being unique, insofar as I know, we are the original producers of compost on a commercial scale made available to the general public at least in the Chicago area. We began producing a surplus beyond our own needs about 1944. Operations have increased steadily and now we produce compost not only in large commercial quantities but of several textures. It is being accepted in ever widening circles. Again without boast, simply as a fact, I claim yet another distinction. To my knowledge there is no other commercial grower, at least in this (Chicago) area, who operates entirely without the use of chemical plant stimulants and poisonous sprays. A sharp contrast in a world of chemicals.

Our present operations include a greenhouse. Growth is as distinctly and proportionately successful under glass as it is out-of-doors. This same measure of success was much in evidence in Florida, where my wife and I sojourned for five years, during which time we engaged primarily in commercial floriculture. Vegetables mainly for our own use were also grown with some surplus for market.

There we had the distinction, according to the inspector from the Florida State Entomologist's office, of having substantially the only insect-free crop of Narcissus bulbs in the State.

Here again, we attribute our unique success to adherence to a soundly biological soil husbandry. All this, notwithstanding the grave warnings to the contrary given by those who were paid for being experts.

Our business is operated for pleasure as much as it is for profit. It yields a just measure of both. It keeps us exceedingly busy, especially at certain seasons. All plants produced by us are, of course, grown in our compost. It is a source of genuine satisfaction to be able to place in the hands of our ever increasing number of customers not only compost-grown plants,

but to provide enough compost to enable them to carry through in their gardening operations.

Finally, to stress the paramount factor of thoroughness, it is so extremely important that there first be a clear realization of the great and urgent need for a reorientation of our thinking from the symptomatic to that of a constitutional nature. We certainly can never build a sound soil economy in any other way than through a well studied and carefully planned biological soil husbandry. Therein alone man can truly and lastingly benefit with the good redounding not only to a given generation, but remaining for posterity as well. When light is shed upon our path it remains for us to make a full commitment of our life's purpose to that which is constructive and creative. Thus may we disentangle ourselves perhaps slowly but very surely from the hopeless labyrinth of artificiality in which many have been ensnared.

DO YOU WANT SOME LAND IN THE COUNTRY?

Farm land is difficult to buy, as you know if you've tried it. A farmer is reluctant to sell an acre or two of good pasture land even to a friend he would like to have as a neighbor. Yet much good farmland is being bought up by speculators and subdivided in such a way that those who want a small but real country place are not satisfied with it. Many requests come into the Association office for "two or three acres somewhere near you there in Chester". We would like to help but cannot find such a thing. Two Bio-Dynamic farmers in our local community have sold off small areas and no more are available. Yet there is a fine farm of 140 acres adjoining the Pfeiffer farm now up for sale. It is fertile, well-treated, rolling land, has the finest views in the neighborhood, with some wooded areas, fine old trees, a beautiful ravine, ample water supply from many springs and fields that the owner has systematically cleared of rocks for 40 years so that one can drive a car across almost any field. Said rocks are piled in certain areas all ready for use in building. Two large farm homes and several barns, well electrified and supplied with water are grouped near the road. The owner, an outstanding dairy farmer and breeder, wants to retire and is asking a good price for his good land. It will probably go to a subdivider. We feel sad at this thought with so many of our friends wishing for rural land. If only they could get together and pool resources or if some person with the Bio-Dynamic ideals and money to invest could buy the place and divide it rightly — what an all round blessing this would be. If you are one who really wants to do something about this, write to the B. D. office for more particulars. We have no time to act as real estate agent, but we should like to help our friends.

Evelyn Speiden
Sec.-Treas. B.-D. F. & G. Assn., Inc.
R. D. 1, Chester, N. Y.